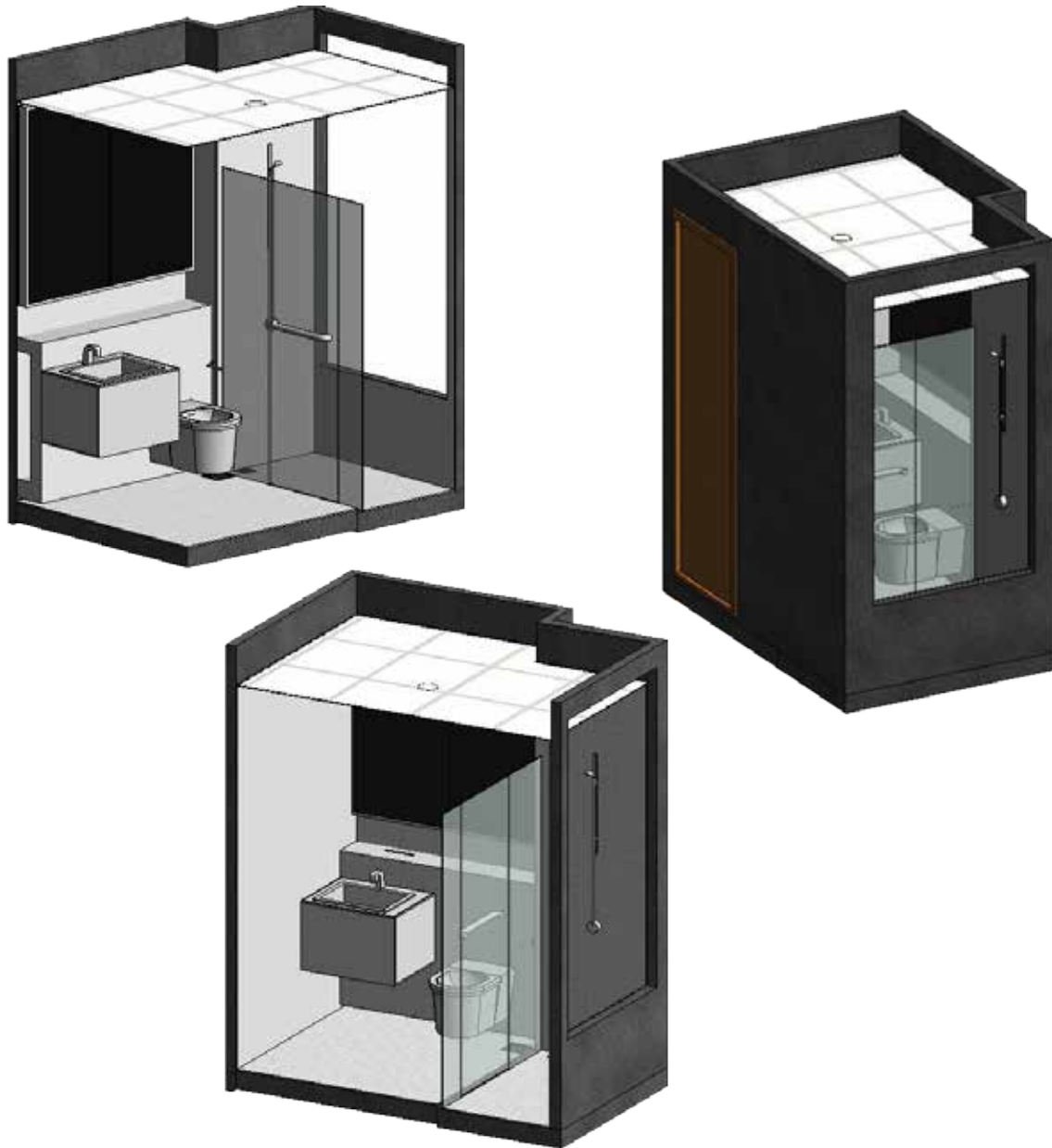


3. PRECAST CONCRETE VOLUMETRIC SYSTEM PBU

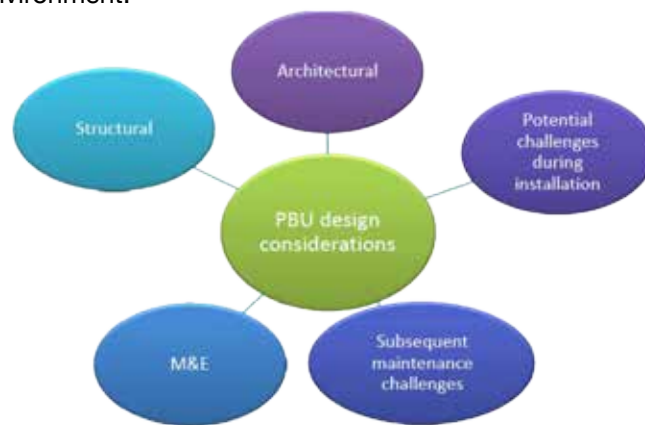


Precast concrete volumetric prefabricated bathroom unit (PBU) is one of the most commonly used PBU systems in Singapore. Its main advantage is its robustness and readiness to accommodate repair and maintenance, which far outweighs the disadvantages posed by its heavier weight and the top down installation method (critical path).

This chapter outlines the considerations in design, production, installation and maintenance of precast concrete volumetric PBU including architectural and M&E work sequence, transportation, lifting and protection, installation and replacement.

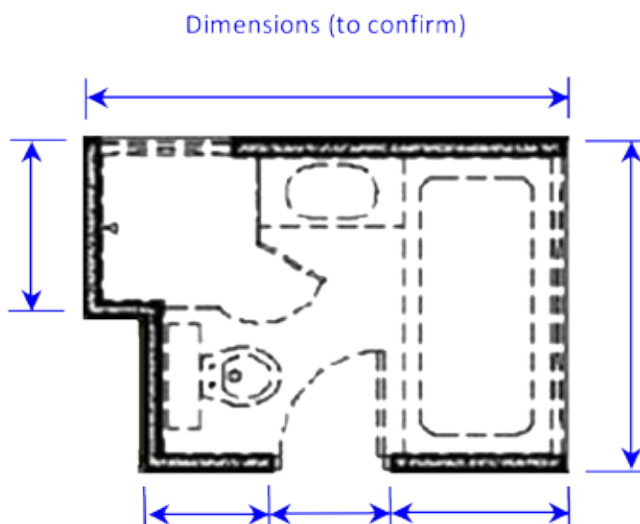
3.1 Design Considerations

Design parameters are critical for any construction work. In the case of PBU, design parameters such as structural, architectural, M&E works, installation, and subsequent maintenance challenges must be determined early to ensure that the PBU system is integrated and can be incorporated in the overall building design. A good PBU design should provide practical solutions to address potential issues arising in different stages of PBU's life cycle including future renovation. It is also important the design meets the requirements in the Code on Accessibility in the Built Environment.



3.1.1 Architectural Design Considerations

a. Dimension



An efficient volumetric system requires careful consideration and confirmation of the overall dimensions. The overall dimensions and design should take into consideration space/floor area taken up by the double wall/floor systems, structural drop slab and storage heater (if any) to ensure effective use of space. The types of bathrooms should be standardized to achieve economy of scale production while providing sufficient design variation.

b. Location of Service Ducts and Access for Maintenance



Gap between PBU and structural slab above can be covered by drywall board.

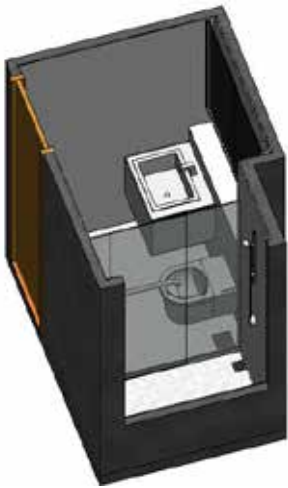
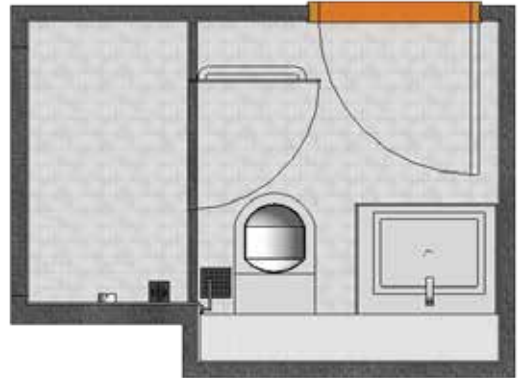
It is a good practice to locate services near to the edge of PBU for ease of future maintenance.

Example of vertical soil stack accessible from within dwelling unit

The routing and connection of services should be predetermined and coordinated with the PBU manufacturer during the design stage.

c. Layout

The locations of door and window openings and layout of fixtures and M&E services should be functional and practical. The formwork mould for volumetric PBU production is dependent on the locations of these openings. It is recommended that the general layout of the prefabricated bathroom unit be provided in the homeowner user manual.



Door



Window



Sanitary Wares

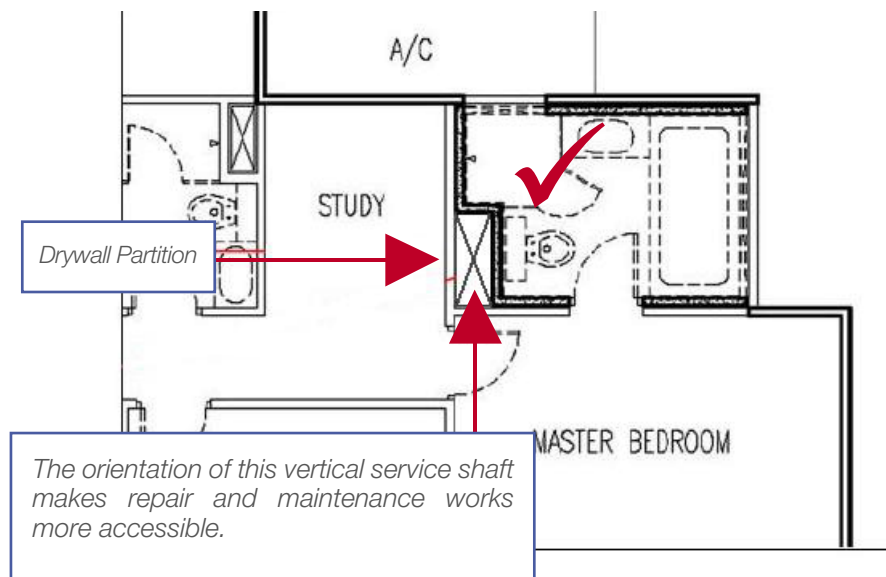


Architectural Fixtures



M&E Services

The location of the service shaft is critical to the maintenance of the precast concrete PBU.

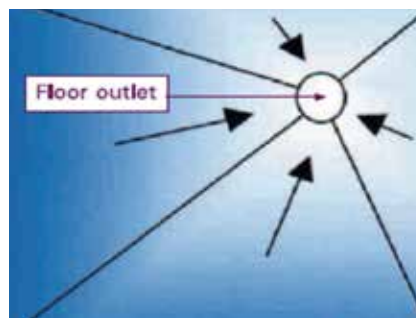


It is important to make the vertical service shaft accessible for future repair and maintenance works of the PBU.

3.1.2 Structural Design Considerations

As precast concrete PUB typically weighs up to 9 tons, it is necessary to ensure that the structural strength of different types of receiving platforms are adequately designed. Use of different types of concrete, such as lightweight concrete or high strength concrete can reduce the overall weight of PBU. The design of the hoisting and lifting devices placed within the precast elements is also crucial to facilitate the installation process. The choice of structural system may have an impact on the buildability score of the project.

a. Double Slab System



Structural design of the secondary slab has to incorporate a gradient to an outlet at the lowest point for drainage.

b. Single Slab System



Perimeter beams for seating PBU



Corbels for seating PBU

c. Lifting and Hoisting Devices



Different types of lifting and hoisting devices

3.1.3 M & E Design Considerations

The design considerations for M&E services will determine the placement and routing methods of these services.



Embedded services within PBU



Recesses/block-outs provided for services



Shallow floor trap



Conventional S or P trap



Cast-in air-con drain pipe



Air-con drain pipe connecting direct to stack

Different ways of routing the air-con drain pipe

3.2 Bathroom Production

3.2.1 Precast Unit Production

A good design and specification of the formwork mould is crucial for producing high quality precast concrete PBU. The steel plate thickness for the precast concrete mould must be sufficiently designed to withstand the concreting pressure. The use of checker plate formwork (for concrete surface receiving finishes) improves bonding between the finished concrete and the adhesive. Proper propping supports should also be provided during the concreting process.



Use of checker plate formwork



Props to formwork

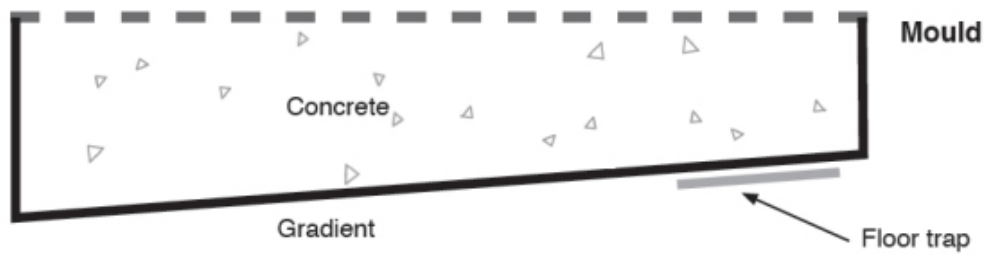


Damage after stripping formwork



Demoulding defects

To improve productivity in the manufacturing process, it is advisable to cast the base slab to the required water gradient (as indicated below) to cut down the screeding process.



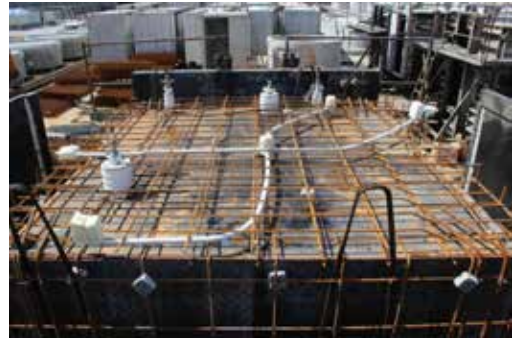
If the slab is cast without gradient, it is important to control the thickness of the screed to achieve the required gradient for water flow.

Please refer to Appendix A - Sample of Inspection and Test Plan

Please refer to Appendix B - Request for Inspection Form



Install reinforcement bars



Install M&E embedded services



Concreting



Secure block-outs



Use of vibrating system to achieve concrete uniformity



Demoulding & curing

*Please refer to Appendix A - Sample of Inspection and Test Plan
Please refer to Appendix B - Request for Inspection Form*

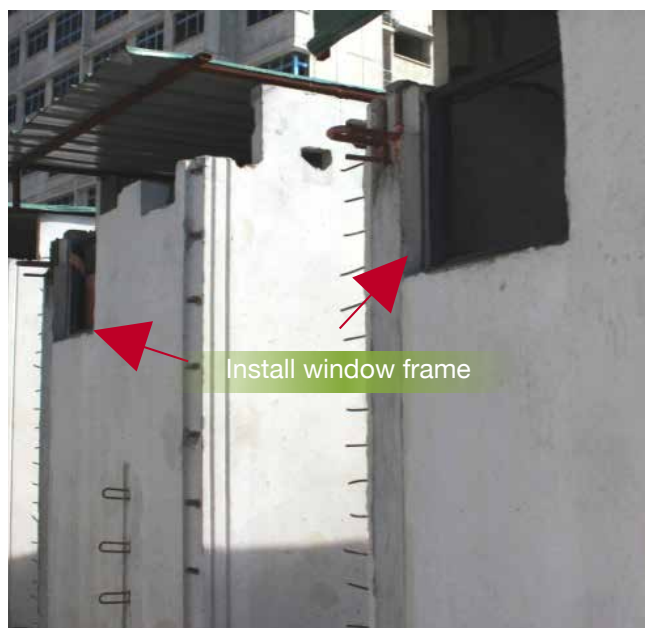
3.2.2 Architectural and M&E Works Sequence

After the completion of precast concrete shell fabrication, the next construction process will be the architectural and M&E works. The application of waterproofing as well as water-ponding test is always an important process towards achieving primary functionality of the PBU. Other key architectural works include fixing of door and window frames, followed by tiling works and installation of sanitary wares and components. Adequate allowance for movement joints should be made for PBU and window and door joints openings.

It is recommended the relevant good industry practices for various trades as in the CONQUAS Enhancement Series http://www.bca.gov.sg/Publications/EnhancementSeries/enhancement_series.html be followed.



Waterproofing system must be tested before receiving architectural works



Door and window frame installation



Tiling works installation



Basin and cabinet



Water closet



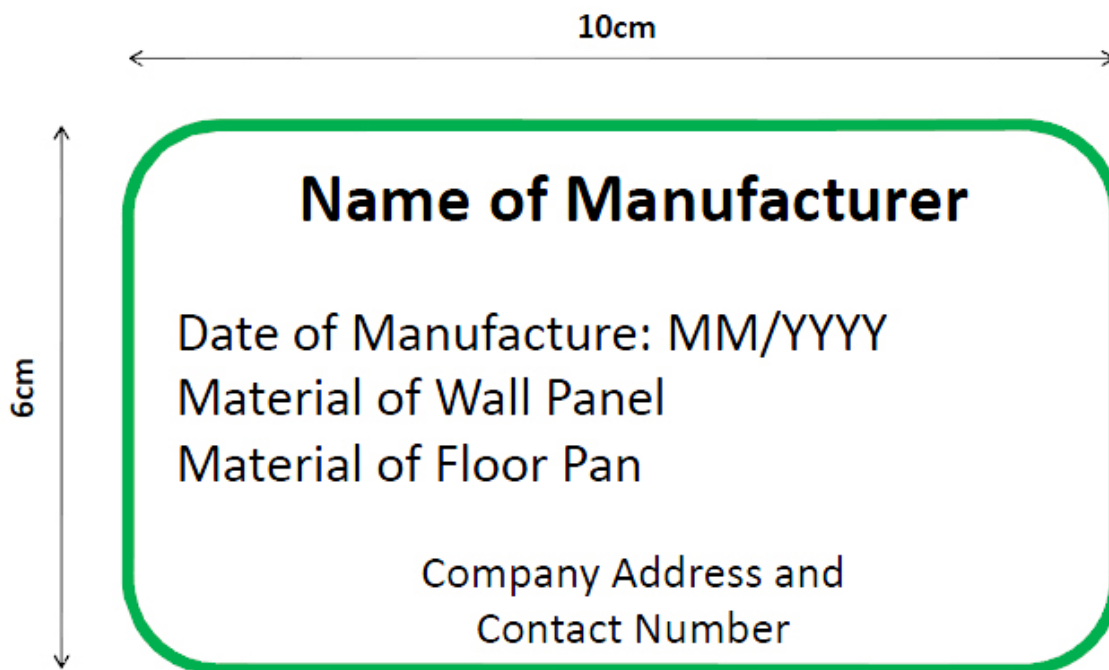
Shower screen



Mirrors

All fragile fixtures can be installed at the last stage of fabrication to minimise possible damage. The architectural internal finishing works should be properly protected before delivery of the precast concrete PBU to site.

3.2.3 Manufacturer's Label



The manufacturer's label should be incorporated in the completed PBU before delivery. This label must be visible to users and should be used as a reference for any repair, replacement and renovation work. It is recommended that the location of the manufacturer's label be provided in the homeowner user manual.

3.3 Protection, Transportation and Lifting

A well-planned transportation, lifting, protection and storage system for the PBU is important to ensure minimal damage to the finished product before and after the PBU is installed at the site.



Sheltered storage facilities eliminate the adverse effects of weather



Delivery of PBU



Protection (to remain) during hoisting



Installation upon delivery

Proper coordination and planning of delivery of PBU can help to resolve the logistical hassle of insufficient storage space, double handling and control of access to the PBU.

3.4 Installation

The readiness of the construction site to receive the PBU is critical to the successful installation of the PBU. It is also important to understand the different structural systems that are designed to receive the PBU at site, viz:

- Double Slab System
- Precast Beam System
- Corbel System



Hoisting of PBU



Positioning PBU (double slab system)



Double slab system



Grouting (double slab system)

The key feature of the double slab system is the fixed dimension of the secondary slab to receive the PBU. It is recommended that the gap between the two slabs be grouted to eliminate any possible water stagnation issues.



Corbel system



Precast beam system for PBU

For precast beam system, the PBU is directly supported on the perimeter beams and hence the positions and dimensions of these beams must be constructed precisely.

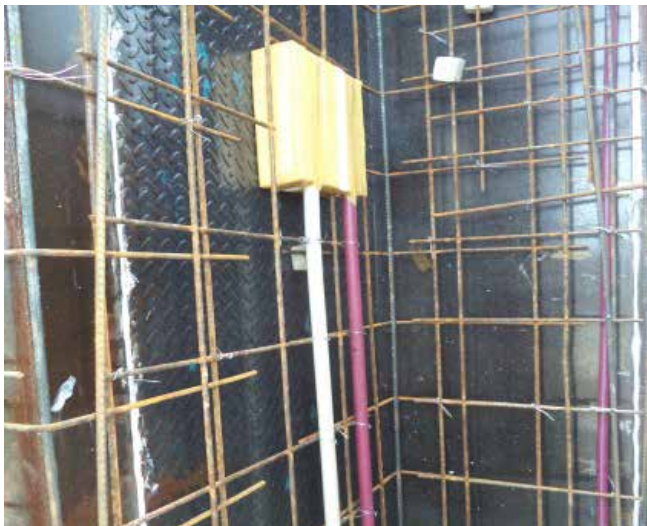
3.5 M&E Connections and Final Fixings

The installation of M&E services and fittings is probably the most critical work process in the entire PBU fabrication as it affects the functionality and serviceability of the PBU. Design for the M&E pipes and duct works shall take into consideration their connectivity to power supply, water supply and sanitary drainage.

3.5.1 Provision for M&E Services

Generally, there are two methods of laying the M&E services in precast concrete PBU. The M&E pipes and conduits can either be cast together with the precast concrete shell or laid via block-outs or recess, which are provided for on the external or internal surfaces of the precast concrete volumetric shell.

For embedded M&E conduits, their positions must be precise and care should be taken to ensure they are properly bent and securely fastened for long-term durability.



Cast-in M&E services on walls



Embedded M&E services on slab

The selection and installation of the embedded electrical conduits should comply with the relevant Code of Practice (CP5 & CP88).

Block-outs and recesses should be sufficiently provided for in accordance to the layout of M&E services for ease of connection to the M&E fittings.



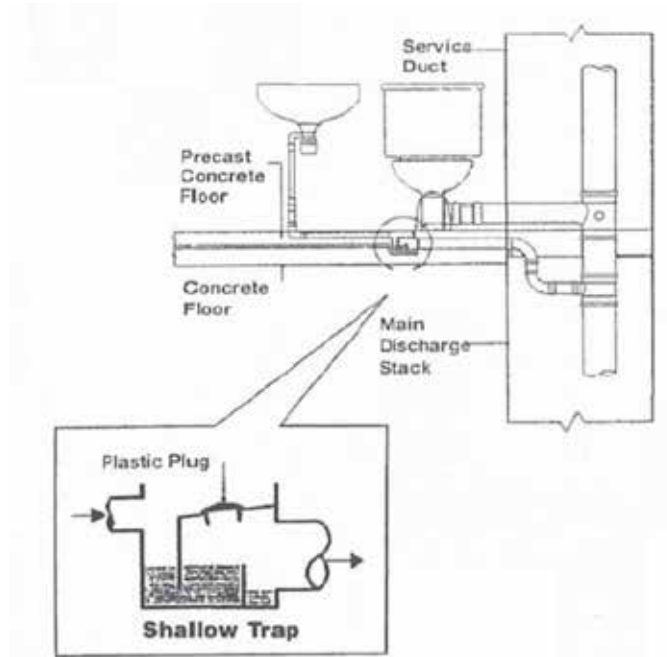
Recess for drainage system



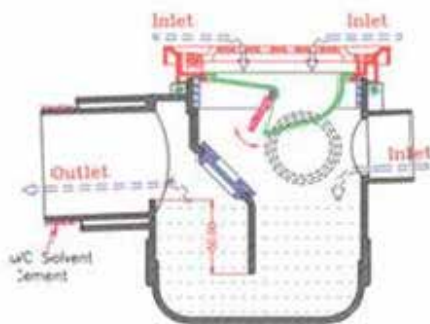
Block-outs for M&E services

3.5.2 Use of Shallow Floor Trap

It is common to utilize a shallow floor trap for PBU with double slab system or when there is constraint in floor height. Unlike the conventional floor trap system where pipes are exposed at the slab soffit, the shallow floor trap and its connecting sanitary pipes are fully concealed in the slab and connected to the main discharge stack directly.



Section drawing of shallow floor trap design

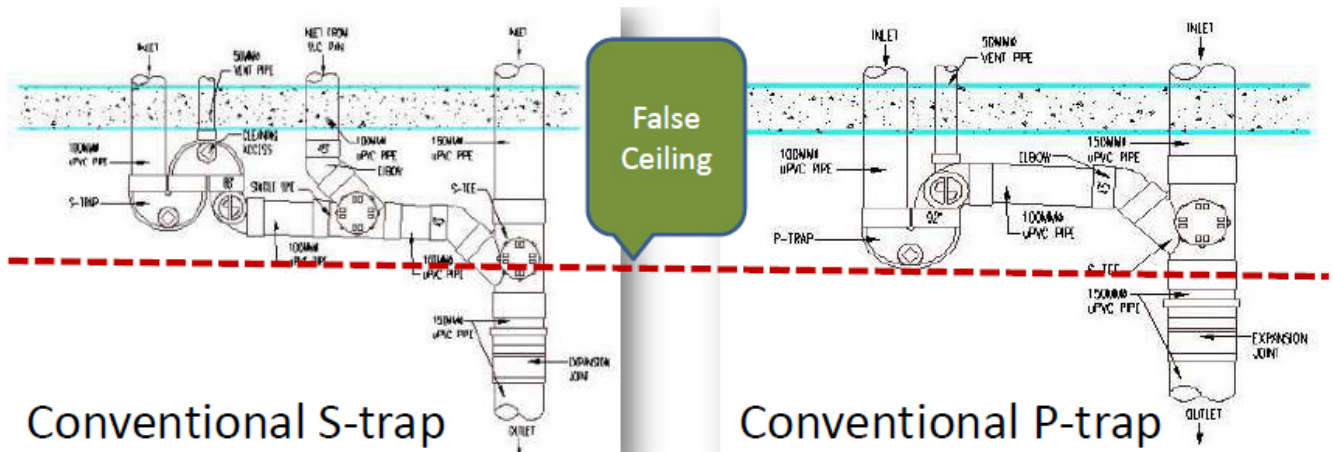


Examples of approved shallow floor traps

In Singapore, the use of shallow floor trap is approved by Public Utilities Board (PUB) if the shallow floor trap is in compliance with EN 1253, which comprises the following 8 tests:

- Anti-blockage test
- Water tightness test
- Flow rate test
- Odour tightness test
- Resistance of water seal to pressure
- Depth of water seal
- Access for cleaning
- Side inlet

3.5.3 Use of Conventional Floor Trap



There is no special maintenance consideration for the use of conventional floor trap in the precast concrete PBU, except for the space required to accommodate the services with the provision of sufficient floor height.

3.5.4 Connection to M&E Fixtures

a. Wash Basin

The water and discharge works for the wash basin in the precast concrete PBU should follow the approved method statements and comply with the relevant Code of Practice for plumbing and sanitary works. Accuracy of the penetration joints from the precast concrete PBU to the connecting accessories (i.e. hoses, taps) of the wash basin is important for its functionality and overall alignment of the wash basin.



Connection and installation of wash basin

Positions and routes of the embedded M&E services should be clearly identified to prevent accidental damage caused by the drilling of anchors and supports for the wash basin.

b. WC Pedestal

Depending on the type of water closet (WC) pedestal used, the plumbing and sanitary connections of the WC may run horizontally through the wall or vertically to the floor slab of the precast concrete PBU. Accuracy of the penetration joints and sleeves from the precast concrete PBU to the accessories of the WC pedestal is important for its functionality and overall alignment. For better aesthetics, the jointing at any pipe penetration should be concealed or covered up neatly.



Horizontal connection to WC pedestal



Vertical connection to WC pedestal



c. Shower Mixer Tap

When there is provision for a shower mixer tap, separate water pipes for hot and cold water should be catered for in the design and fabrication of the precast concrete PBU shell. The routing of the different water pipes could be demarcated by coloured tapes on the finished wall surfaces for clear identification of these pipes.



Connection of shower mixer tap on wall



Demarcation of hot and cold water supply by coloured tapes

3.5.5 Routing of Air-conditioning Drain Pipes

Air-conditioning drain pipes are normally laid through the wall and floor slab at a gradient to discharge condensate water to the PBU floor trap. The air-conditioning drain pipes could be designed to run embedded in the precast concrete PBU floor slab connecting to the floor trap. An alternative is to run the insulated drain pipes through the false ceiling (if available) and connect directly to the discharge stack.



Cast in air-con drain pipe



Running insulated air-con drain pipes at ceiling and connect to a separate stack pipe

3.6 Maintenance, Replacement and Renovation

There are differences in the maintenance, replacement and renovation of precast concrete volumetric PBU as compared to conventional toilet. Therefore, it is important for developers and builders to provide a homeowner user manual upon completion of project for instructions and advice on how to maintain, replace and renovate the PBU.



Use of breaker to hack tiles during renovation



Hammer and chisel method used for replacement and maintenance work

As the wall and floor of precast concrete PBU may not be as thick as conventional toilet, the selection of appropriate tools and use of recommended methods of work execution can prevent damage to the precast concrete PBU. The types of tools and execution methods must be covered in the homeowner user manual.

3.6.1 M&E Concealed Services



M&E embedded services (cast-in)



M&E concealed services routing through precast block-out

For M&E services that are cast-in with concrete, both the tiles and concrete need to be hacked during repair works. For M&E services that are laid through block-outs, removal of tiles or surface finishes should suffice.

Hence, it is essential to provide the M&E concealed services locations through drawings and demarcation of route in the homeowner user manual. This can help homeowners and renovation contractors minimize damage during repair and replacement of M&E concealed services.

3.6.4 Ceiling Access Panel



Ceiling Access Panel Location

The ceiling access panel is a common provision for toilets with false ceiling. The function of the access panel within the precast concrete PBU is to access and maintain all M&E works above the false ceiling, similar to that for conventional toilet.

3.6.5 Replacement of Other Items



Replacement of sanitary ware



Replacement of shower screen



Replacement of bathroom cabinet



Replacement of M&E piping



Replacement of shower mixer tap

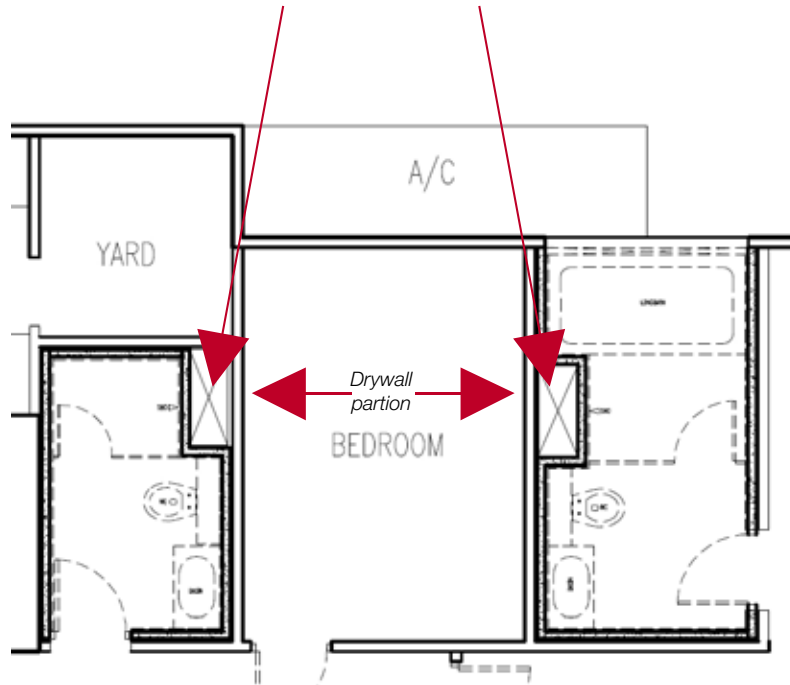


Replacement of shower bar

The replacement of sanitary items and components within the PBU is similar to that for conventional toilet.

It is recommended that the method of removal and access to the M&E stack shaft be covered in the homeowner user manual. PBU designers should also explore other possible options to access the stack shaft.

Stack pipe shaft is accessible for maintenance on side of drywall partition



Example of service duct access to stack pipe shaft



Example of an accessible stack pipe shaft